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Refereed paper

Quality indicators to measure blood pressure management over a time interval

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ABSTRACT

Background Quality indicators are an important part of the primary care landscape, but focus strongly on point-in-time measurements, such as a patient's last blood pressure (BP) measurement. There is a larger space of possible measurements, including ones that more explicitly consider management over an interval of time.

Objective To determine the predictive abilities of five different quality indicators related to poor BP control.

Methods Data from two New Zealand general practices was analysed on five BP control indicators for patients with diagnosed hypertension: 1) last BP high (>150/90 mmHg); 2) last BP high or no BP measurement; 3) two or more consistently high BP measurements for ≥90 days; 4) a high BP then lapse of >120 days in BP measurement; and 5) antihypertensive medication possession ratio (MPR) of <80%. Probability that a patient would be identified by each indicator for the nine-month evaluation period ending 31 March 2009 was computed for each indicator one quarter, two quarters and three quarters prior to this date. Associations among the five indicators for the evaluation period were also calculated.

Results Positive predictive value (PPV) of indicators for the same indicator nine months later ranged from 27% (last BP high) to 64% (MPR). PPVs among the five measures with respect to the same time period ranged from 9% to 77% (median 33%).

Conclusions Modest PPVs between indicators suggest the importance of considering multiple indicators to incentivise best management across diverse aspects of BP control.

Keywords: clinical audit, long-term care, patient outcome assessment, quality and outcomes framework, quality indicators

Introduction

Despite various efforts to control blood pressure (BP) to below recommended limits, only 41.9% of treated patients with hypertension are reported to have controlled BP.[1] High BP has been suggested as the most important risk factor for cardiovascular disease (CVD) – a British study reported that controlling all hypertensive patients to a systolic BP of $\leq$140 mmHg would yield a reduction of 28–44% in stroke and 20–35% in ischaemic heart disease, resulting in a total of 125 600 events a year saved in the UK.[2]

The medical community in general accepts that following well developed, evidence-based clinical practice guidelines improves the quality of care received by patients along with the many other benefits guidelines provide.[3] Together with guidelines, quality indicators are often used in order to provide feedback to clinicians and to give an indication of the quality of patient care delivered. There have been national level efforts to develop quality indicators for primary care, notably from Canada,[4] New Zealand,[5] Denmark[6] and the UK.[7] The Quality and Outcomes Framework (QOF) in the UK[7] is perhaps the world's single largest attempt to improve the quality of primary care[8] (see Box 1).

The key QOF indicator 'BP5' uses the notion of the 'last BP' being controlled. Previously,[9–11] we developed several quality indicators with a strong association to temporal intervals (an *evaluation period*), rather than focusing on a single measurement at one point in time. The QOF's BP5 suggests that its framers saw relevance in nine months as an appropriate evaluation period (and, we acknowledge, in this sense BP5 is at least partially interval based). In this paper we examine five BP quality indicators ranging from a completely point-in-time 'last BP high' measure to a range of more interval-oriented indicators. We look at their stability (ability to predict the same indicator) over time and their association with each other. We use routinely collected data from two general practices in New Zealand for illustration.

Box 1 The Quality and Outcomes Framework and 'point-in-time' indicators

The QOF was first introduced in April 2004 as part of the General Medical Services contract. It provides a set of clinical indicators across four domains (clinical, organisational, additional services and patient experience)[7] designed around best practice in order to improve the quality of service provided to patients. Each indicator is allocated a number of points and GP practices are awarded points according to how well they have performed, with associated monetary compensation. The indicators are updated annually.

Most of the widely used quality indicators use the presence of a single point-in-time measurement to determine whether a given indicator is satisfied. For example, an important QOF indicator related to the ongoing management of patients with hypertension, the one with the highest point allocation (57 QOF points) in the 'clinical' domain, is BP5: 'The percentage of patients with hypertension in whom the last blood pressure (measured in the previous nine months) is 150/90 or less'.[7]

Methods

Quality indicators

In previous work on indicators based on electronic medical records (EMRs) we developed audit criteria to identify hypertensive patients who needed follow-up. The researchers had iterative discussions with an expert panel from a general practice, including the practice manager, two general practitioners (GPs) and practice nurses. These discussions yielded eight indicators of quality improvement opportunities, which were subsequently validated.[9] Two indicators (with modified thresholds for comparability) are relevant to BP5:

> 'patients classified with hypertension with two or more consistently high BP measurements (>150/90 mmHg) over 90 days or more where either (i) the last of these high BPs was within the evaluation period or (ii) with no subsequently 'controlled' BP ($\leq$150/90 mmHg) measurement after the consistently high BPs'

and

> 'patients classified with hypertension with a BP measurement >150/90 mmHg followed by a gap of >120 days in BP measurements extending into the evaluation period'

The 'evaluation period' was nine months in the present study, in order to be consistent with the BP5 indicator used in QOF. We use the six-month period prior to the evaluation period as a 'run-in' period to account for intervals of suboptimal management that begin before the evaluation period but extend into it.[10] We also use an indicator of medication adherence, medication possession ratio (MPR, percentage of days a patient had medication supply during an evaluation period) and take MPR<80% as the indicator level. Details related to MPR and the importance of it for BP control have been reported previously.[10] Similar to our previous studies,[10,12] we use EMR prescribing data to determine MPR.

Data extraction

We extracted data for the 24-month period from 1 April 2007 to 31 Mar 2009 with the exception of classifications (problems coded using Read Clinical Codes[13]), which were extracted for the previous five years. The details of the two datasets extracted from the practices' EMRs are shown in Table 1. Only funded patients enrolled at the practices were included (all New Zealand citizens and permanent residents can be enrolled with one primary healthcare organisation which is funded for management of that person; each general practice is associated with a primary healthcare organisation). Practice 1 serves a largely Pacific (particularly Samoan) community in metropolitan suburbs; Practice 2 serves a largely European community in a regional city.

Table 1 Summary of the two practice data sets for funded and enrolled patients

	Practice 1	Practice 2
Funded and enrolled patients	5454	4260
Patients with classifications	4422	3718
Hypertension	602	674
BP measurements	11 977	9986
Prescriptions	61 840	48 564
Antihypertensives	7663	9981

Analysis protocol

We analyse failure rates as of the end of the first quarter of 2009 using five different quality indicators: 1) last BP high (>150/90 mmHg); 2) failing BP5; 3) consistently high BP; 4) high BP then lapse; and 5) MPR<80%. Failing BP5 in fact consists of two patient cohorts – patients with BPs where the last BP was not controlled (i.e. explicitly high, equivalent to 'last BP high'), and patients who do not have a BP measurement during the nine-month period. Using the five quality indicators, we determine prediction rates at one quarter, two quarters and three quarters of the year prior to the evaluation date to determine the suitability of each indicator to accurately predict patients who will continue to fail each aspect of quality BP management. The dates of interest are illustrated in Figure 1.

Using the timelines in Figure 1, we first compute the various rates of failure (i.e. the patient having the specific deficiency in GP management) as predicted by the same indicator three-months, six-months and nine-months prior to 31 March 2009. In terms of conditional probability, the probability that a patient will fail an indicator given that the patient failed at a prior date is given by:

$$p(t \mid (t-k)) = \frac{p(t) \cap p(t-k)}{p(t-k)}$$

where $p(t)$ indicates the probability that a patient will fail the indicator during the current evaluation period while $p(t-k)$ indicates the probability that a patient will fail the indicator during a time period prior to the evaluation period (with k of three months, six months and nine months). This conditional probability is equivalent to the positive predictive value (PPV) of the indicator at time $t-k$ for the indicator at time t.

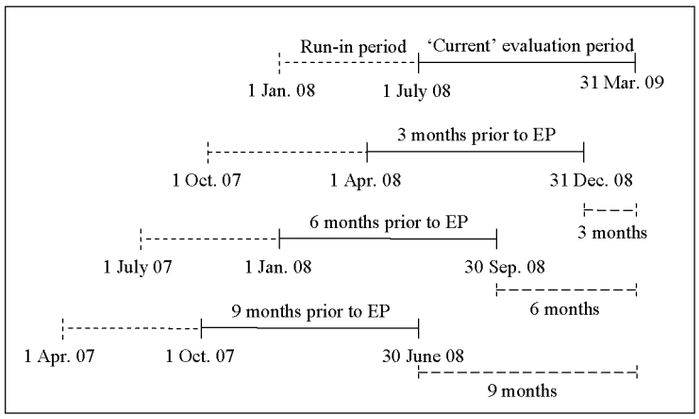

Figure 1 Timelines related to the quality indicator analysis

To assess the degree to which the indicators agree with one another (and hence are potentially 'redundant') we look at the conditional probability of a patient failing one indicator given that they have failed another with respect to the most current evaluation period. Again, this conditional probability is equivalent to PPV.

Note that for the MPR criterion there is an additional inclusion constraint that a patient is required to have at least one antihypertensive prescription during the 15-month period (i.e. during the run-in period or the evaluation period).

Results

From Practice 1 and Practice 2 respectively, 535 and 598 patients were funded and enrolled at 1 July 2008 and had a hypertension diagnosis; of these, 459 (86%) and 562 (94%) patients, from Practice 1 and Practice 2 respectively, satisfied the additional inclusion criterion for computation of MPR. The predictive abilities of the five indicators are shown in Table 2.

These results show that 'last BP high', a point-in-time measure, is less stable than the other, interval-oriented indicators. Failing BP5 ranks reasonably well; its PPV is generally under that of consistently high BP, high BP then lapse and MPR<80% for the three-month and six-month prior intervals, but this is owed in part to the interval measures being correlated by definition when the time periods overlap. MPR<80% is the most stable criterion among the five indicators considered.

Table 3 and Table 4 show the PPVs between quality indicators for the two practices at time t; for those PPVs for which 100% is not definitional the median is 33% (min = 9%, max = 77%).

Table 2 PPVs of quality indicators based on past performance on same indicator

k	Practice	Last BP high	Failed BP5	Consistently high BP	High BP then lapse	MPR<80%
3 months	Practice 1	65/118 = 55%	133/190 = 70%	29/39 = 74%	94/118 = 80%	143/166 = 86%
	Practice 2	34/77 = 44%	60/105 = 57%	27/35 = 77%	22/27 = 82%	80/99 = 81%
6 months	Practice 1	56/142 = 39%	116/198 = 59%	27/51 = 53%	63/101 = 62%	133/184 = 72%
	Practice 2	31/85 = 37%	53/113 = 47%	18/38 = 47%	13/24 = 54%	71/110 = 65%
9 months	Practice 1	49/156 = 31%	108/210 = 51%	22/45 = 49%	38/82 = 46%	121/188 = 64%
	Practice 2	26/96 = 27%	46/124 = 37%	16/41 = 40%	10/22 = 46%	59/104 = 57%

Denominator is patients failing in evaluation period ending at time $t - k$; numerator is patients failing on 'current' evaluation period (ending at time t) and also failing in evaluation period ending at time $t - k$

Table 3 PPVs between different indicators for Practice 1

Given	Last BP high *n* (%)	Failed BP5 *n* (%)	Consistently high BP *n* (%)	High BP then lapse *n* (%)	MPR <80% *n* (%)
Last BP high ($n = 99$)	99 (100)	99 (100)	21 (21)	47 (47)	50 (51)
Failed BP5 ($n = 179$)	99 (55)	179 (100)	22 (12)	60 (34)	77 (43)
Consistently high BP ($n = 38$)	21 (55)	22 (58)	38 (100)	22 (58)	17 (45)
High BP then lapse ($n = 109$)	47 (43)	60 (55)	22 (20)	109 (100)	64 (59)
MPR<80% ($n = 163$)	50 (31)	77 (47)	17 (10)	64 (39)	163 (100)

The values indicate the number of patients failing an indicator given another indicator failed by n patients, followed by the corresponding probability (as a percentage)

Table 4 PPVs between different indicators for Practice 2

Given	Last BP high *n* (%)	Failed BP5 *n* (%)	Consistently high BP *n* (%)	High BP then lapse *n* (%)	MPR<80% *n* (%)
Last BP high ($n = 75$)	75 (100)	75 (100)	12 (16)	25 (33)	21 (28)
Failed BP5 ($n = 106$)	75 (71)	106 (100)	12 (11)	27 (25)	32 (30)
Consistently high BP ($n = 24$)	12 (50)	12 (50)	24 (100)	8 (33)	9 (38)
High BP then lapse ($n = 35$)	25 (71)	27 (77)	8 (23)	35 (100)	22 (63)
MPR<80% ($n = 101$)	21 (21)	32 (32)	9 (9)	22 (22)	101 (100)

The values indicate the number of patients failing an indicator given another indicator failed by *n* patients, followed by the corresponding probability (as a percentage)

Visualisation

As part of the ChronoMedIt framework,[12] we developed a graphical tool that can be used to visualise a patient's prescribing patterns together with laboratory measurements or physiological outcomes, such as BP. The use of this visualisation tool on a selected patient results in the plots shown in Figure 2.

The patient shown in Figure 2 has been classified with hypertension and has failed all five indicators. The last BP is high and therefore satisfies the 'last BP high' and 'failed BP5' indicators. There are two or more consistently high BPs as all three measurements are high with the difference between first and last high BPs being 386 days. Two instances of high BP then lapse can be observed in Figure 2: 1) 218 days between first and second BP measurement; and 2) 168 days between second and third BP measurement. Also, there are two lapses in antihypertensive therapy (a lapse of 42 days from 26 August 2008 to 7 October 2008 and of 78 days from 5 January 2009 to 24 March 2009); thus there is total of 120 days without medication during a 273-day evaluation period, and MPR = (273–120)/273 = 56.04%, therefore the patient fails the MPR<80% indicator.

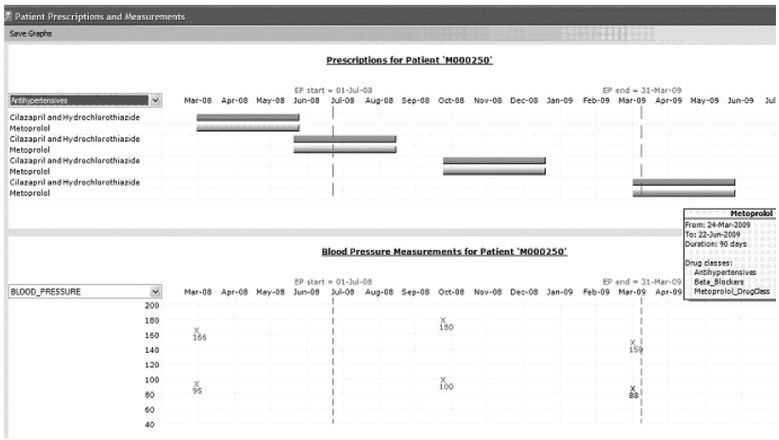

Figure 2 Prescribing patterns and BP measurements for a selected patient. The tooltip shows further information about the selected prescription. The three BP measurements correspond to 3 March 2008, 7 October 2008 and 24 March 2009

Discussion

Significance

This paper illustrated a range of interval-based quality indicators around management of BP. Our results indicate that MPR<80% is the most stable measure, and that all interval-based measures are more stable than the point-in-time measure of 'last BP high'. In our previous research, we showed that nearly a third of patients satisfying the QOF BP5 criterion fail at least one of the related interval-based measures; however, all the indicators demonstrated herein are important for actively identifying and managing patients on suboptimal BP control, and the low PPVs shown in Table 3 and Table 4 indicate that relying on a single measure is not sufficient as the cohorts identified by each indicator are considerably different. Therefore, our proposition is that although point-in-time measures are important, they are not sufficient to represent successful BP control. Notably, with respect to the QOF, there is warrant to extend this framework to include indicators that consider BP measurements over time, and perhaps to consider introducing other process measures such as MPR. Providing clinicians with lists of patients who satisfy such indicators may assist them to actively manage those patients and ultimately achieve and maintain satisfactory BP control.

Table 2 shows that at least 74% of the patients from both practices who failed consistently on high BP, high BP then lapse and MPR at the end of 2008 continued to fail these criteria at the end of the first quarter in 2009, demonstrating detectable opportunities for improved case management. It is interesting to note from Table 2 that almost all the probabilities are higher for the Pacific practice than for the European practice. This is not a surprising result per se, as research has shown that Maori/Pacific populations have a higher CVD risk compared with other ethnic groups.[14]

Related work

The specific criteria we have discussed herein (except 'last BP high') focus on evaluating clinical outcomes with respect to time intervals rather than points in time. Several other studies have also proposed such indicators,[15,16] for example, a set of systematically developed primary care quality indicators for hypertension included the 'Percentage of patients with an average systolic BP greater than 160 mmHg and/or a diastolic BP greater than 100 mmHg, as determined on at least three separate visits, who have a diagnosis of hypertension recorded'.[16] It has been shown that assessing BP control based on a single measurement and/or a single visit is unlikely to be reliable, but BP considerations over time result in significantly fewer patients achieving targets set forth by guidelines.[15] The interval-based measures proposed herein also strongly relate to the guidelines[17] by the National Institute for Health and Clinical Excellence (NICE) in the UK which suggest (recommendation R71) monitoring BP of a person who has attained and consistently remained at his or her BP target every four to six months, and checking for possible adverse effects of antihypertensive therapy – including the risks from unnecessarily low blood pressure.

Limitations and future directions

This study has several limitations. The results are based on just two general practices, and these particular practices were selected opportunistically (in part representing the authors' links and interest with respect to Pacific health), therefore our results may not generalise across a population. Also, we have not examined differences in management and outcome with respect to ethnicity (or any other demographic details) in the present study – this is a worthy direction to take, but would require a larger, randomised sample. It is worth noting that the QOF has provision for exception reporting (i.e. a scheme whereby practices can exclude patients who do not meet the QOF criteria due to a range of reasons, such as doctors being unable to prescribe due to contraindications/side-effects),[1] and if the two practices were in a UK setting it is likely that some of the patients in our study populations would be excluded via exception reporting due to difficulties in achieving goal BP. Moreover, we have not considered the impact of known issues with respect to BP measurement in primary care, for instance, the known end-digit preferences when recording BP.[18] Also, we have used general practice *prescribing* data for the MPR-related statistic – we have previously shown that prescription based analysis of adherence to long-term medications is a useful predictor of dispensing-based adherence, with patients non-adherent in prescribing being 81% non-adherent in dispensing.[19] However, even if the prescribed medication was dispensed, there is no guarantee that the dispensed medication was subsequently consumed as directed. Extension to include dispensing data, or even home monitoring, would obviously result in superior 'intelligence' and is a desirable future direction.

A single point-in-time measure of a physiological variable with established links to morbidity and mortality (such as a target BP) can be seen as an outcomes-oriented measure. In contrast, the MPR criterion is a process-oriented measure, focusing on the quality of care delivery. The five specific criteria examined

herein may at first appear somewhat arbitrary; however, they represent a continuum in progression from point-in-time direct outcomes to more process-oriented measures that aim to represent the quality of care over the entire evaluation period. Point-in-time, outcomes-based measures are important; for instance, the QOF has been associated with positive outcomes such as improved BP monitoring and control[20,21] and better and more equitable management of coronary heart disease across ethnic groups.[22] However, as discussed in this paper, it is also important to integrate some of the interval-based measures that take into account the context of an entire evaluation period. The QOF has been a bold initiative by the UK; developing quality indicators for performance measurement efforts (irrespective of whether they are linked to financial incentives) is an ongoing effort, and countries such as the USA and NZ are drawing upon lessons learnt from the QOF in an attempt to enhance their current primary care healthcare systems and processes.[23,24]

Conclusions

Considering only point-in-time measurements, such as a patient's last BP measurement, may not be the most reliable approach in measuring and predicting suboptimal BP control. New methods that consider time intervals as opposed to just point-in-time measurement have the potential to improve the identification of suboptimally managed patients.

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ETHICS

This study was approved by the New Zealand 'Northern X' Regional Ethics Committee as protocol NTX/09/100/EXP. Patient confidentiality was protected by withholding identifying patient details (name, address and National Health Index number) from the University based researchers. However, a practice-specific patient identifier was provided to the researchers (e.g. 'M004162') so that the clinicians working for the practices could still identify the patients for clinical follow-up.

CONFLICTS OF INTEREST

There are no direct conflicts of interest, however, custom analysis software used in the present study, ChronoMedIt, is the intellectual property of Auckland UniServices, the commercial arm of the University of Auckland; the first two authors have inventors' rights in this software.

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